

7 Processes that Enable NASA Software Engineering Technologies

Value-Added Process Engineering

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Agenda

- Agency Process Requirements
- 7 Software Engineering Processes
 - Purpose, Benefits, and Experiences
- Honorable Mention

NASA's Software Engineering Requirements

- Software engineering is a core capability and key enabling technology for NASA's missions and supporting infrastructure
- NASA Software Engineering Requirements (NPR 7150.2A)
 - Provide a minimal set of requirements established by the Agency for software
 - Applies to all software created by or for NASA – during all phases
 - For use by both the contractor and in-house communities
 - Support NASA programs/projects to accomplish planned goals (e.g., mission success, safety, schedule, and budget) while satisfying specified requirements
 - Are implemented through Center-specific process definition documents

NPR 7150.2A CMMI Requirement

- [SWE-032] The project shall ensure that software is acquired, developed and maintained by an organization with a non-expired Capability Maturity Model Integration® for Development (CMMI-DEV) rating as measured by a Software Engineering Institute (SEI) authorized lead appraiser as follows:
 - For Class A software: CMMI-DEV Maturity Level 3 Rating or higher for software, or CMMI-DEV Capability Level 3 Rating or higher in all CMMI-DEV Maturity Level 2 and Maturity Level 3 process areas for software.
 - For Class B software: CMMI-DEV Maturity Level 2 Rating or higher for software, or CMMI-DEV Capability Level 2 Rating or higher for all Maturity Level 2 process areas.
 - For Class C software: The required CMMI-DEV Maturity Level for Class C software will be defined per Center or project requirements.

	CMM Level 2	CMM Level 3	CMMI Level 2	CMMI Level 3
2000	MSFC			
2001				
2002	JSC			
2003	LaRC/ARC	MSFC/ARC*		
2004	GRC	JSC		
2005	JPL/JSC		MSFC	
2006			GSFC	
2007				MSFC/JPL
2008			LaRC (FSSB)	LaRC (FSSB) *
2009			JSC/KSC/LaRC	LaRC (SDAB) *
2010			MSFC (SIL)/ARC/GRC	MSFC (FSW)/JPL

* Partial implementation

What's your frustration?



Lack of planning?

Vague requirements?

Poor Quality?

7 Product Integration

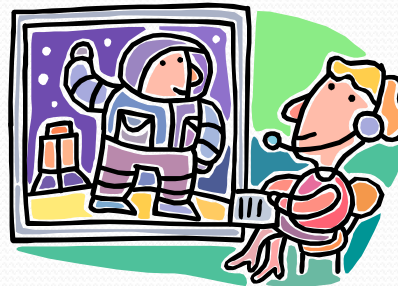
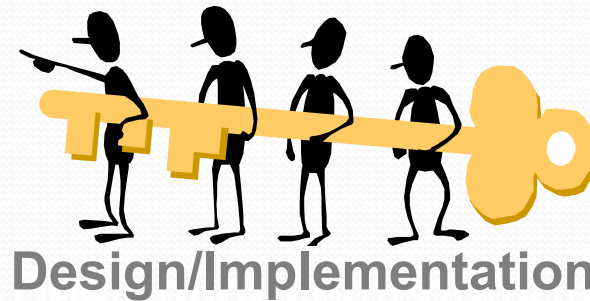
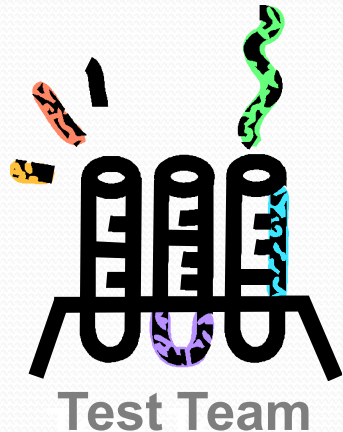
- Product integration is the assembly of software components to ensure correct product functionality
 - Product integration is:
 - a highly critical and non-trivial part of the development
 - frequently overlooked during planning phase
 - Critical elements of product integration include:
 - defining and implementing the integration environment
 - management of interfaces
 - component integration sequences
 - communication between stakeholders
 - For software systems, integration is typically the first opportunity to observe implementation results

7 Product Integration

- Benefits
 - Exposes and drives out defects prior to formal testing
 - Reduces costs for error correction and re-testing
 - Can reduce the length of formal testing (fewer error corrections necessary)
 - Last opportunity to create new functionality before formal test begins
 - Encourages well-defined interfaces and components for easier inspection, integration, and automation
 - Increases the probability for high quality products and timely deliveries to verification and validation activities

7 Product Integration

- Who makes it happen?



6 Configuration Management

- Configuration Management (CM) establishes and maintains the integrity of specified work products
 - Typically the most misunderstood and under appreciated process
 - Fundamental CM involves ...
 - Identifying configuration items
 - Controlling changes to configuration items
 - Establishing a CM system that supports control objectives
 - Sustaining integrity of baseline products
 - Maintaining accurate status of configuration data

6 Configuration Management

- Benefits

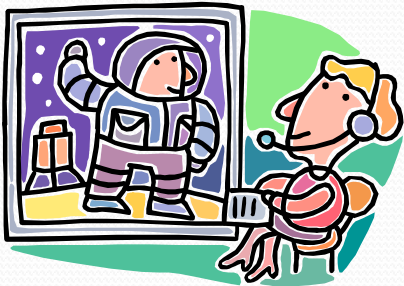
- Baselines provide a stable foundation for continuing evolution of specified work products
- Build Variance Detection
 - Knowing the last known good build, changes can be effectively detected and examined or rolling back to the last known good configuration can be achieved
- Effective Change Management
 - Knowing the configuration of a given CI saves time that would be spent figuring out the configuration versus being able to immediately engineer the change in the known configuration

6 Configuration Management

- Benefits (cont'd)
 - Enhanced Ability to Rebuild
 - If a CI fails or is involved in a disaster, it is far easier to rebuild if the final production build of the CI is known
 - Assists with Cost/Schedule Estimating
 - Understanding what software goes into a given CI allows for proper costing to serve as an input to planning and estimating process

6 Configuration Management

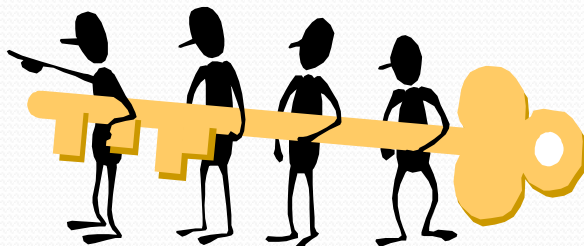
- Who makes it happen?



Configuration Management



Requirements Team

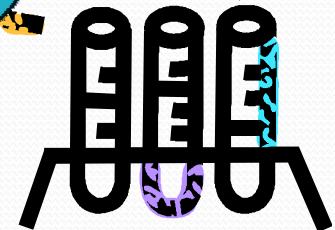


Design/Implementation



Project Management

Everybody!!!



Test Team

5 Verification

- Software verification is a broad and complex software engineering discipline that ensures transitional and final work products adhere to their specified requirements
- Growth in complexity of designs increases the importance of formal verification techniques
- Key concepts include ...
 - Select verification work products
 - Establish verification environment/procedures/criteria
 - Perform verification

5 Verification

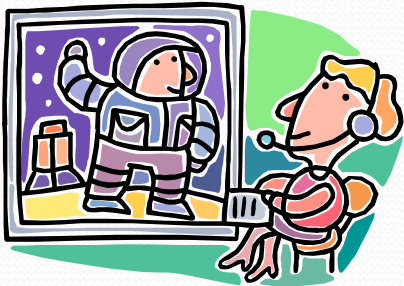
- Benefits
 - Requirements Phase – Ensure requirements are verifiable, achievable, actionable, measurable, related to identified business needs, and defined to a level of detail sufficient for system design
 - Design Phase – Review/analysis using models, simulations, and prototypes

5 Verification

- Benefits (cont'd)
 - Implementation Phase – Analysis to help detect complexity, memory, arithmetic exception, out-of-bounds array access, and coding standard problems
 - Test Phase – verifies software as implemented. It addresses specified requirements and ONLY specified requirements
 - Peer Reviews - one of the most effective methods of verification since they improve product quality by detecting errors as early as possible

5 Verification

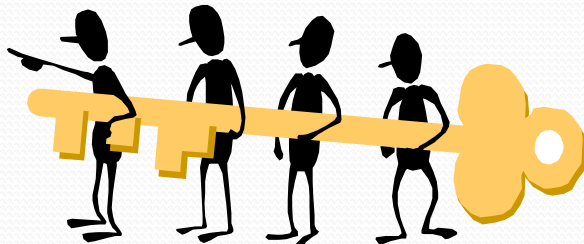
- Who makes it happen?



Configuration Management



Requirements Team

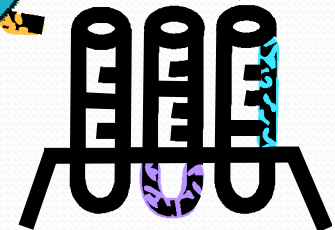


Design/Implementation



Project Management

Everybody!!!



Test Team

4 Software Assurance

- Product assurance provides management and staff an objective evaluation of organizational processes and associated work products
- Key concepts include ...
 - Objectively evaluate processes/products against specified standards
 - Document non-compliance issues and provide feedback to management and staff
 - Ensure non-compliances are addressed

4 Software Assurance

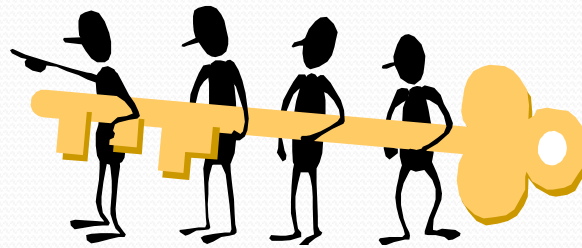
- Benefits
 - Product assurance provides insight into process implementation as compared to process definition
 - Identifies process improvement opportunities
 - Monitors process implementation effectiveness
 - Ensures critical work products align with specified standards in support of customer/contract requirements
 - Provides management with visibility into process effectiveness and product quality

4 Software Assurance

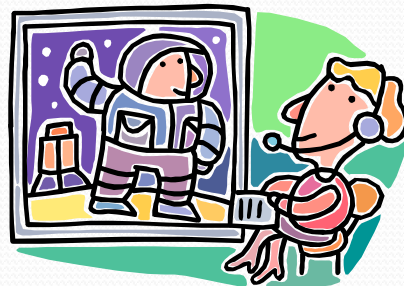
- Who makes it happen?



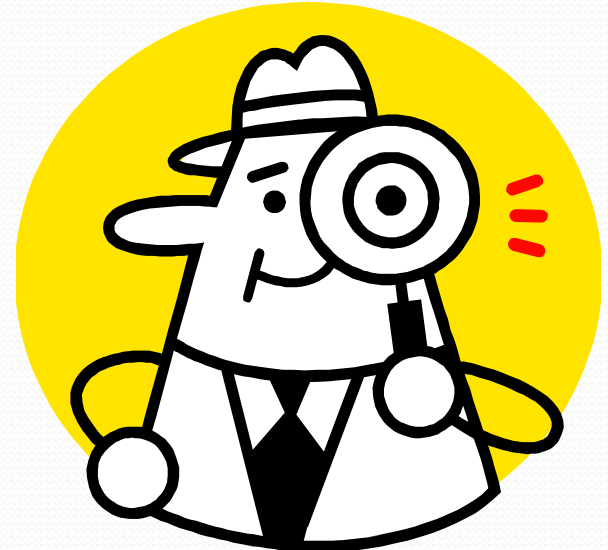
Requirements Team



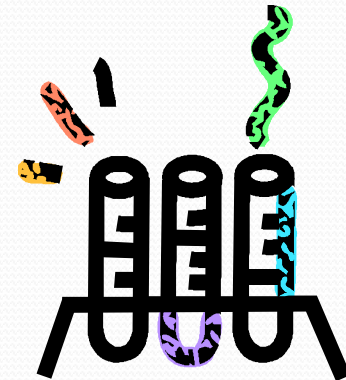
Design/Implementation



Configuration Management



Software Assurance



Test Team

3 Measurement and Analysis

- Measurement and analysis defines and maintains a measurement capability that supports management information needs as they relate to mission objectives
- Key concepts include ...
 - Identify mission objectives
 - Derive measures from mission objectives
 - Select analysis techniques
 - Define data collection, storage, and reporting mechanism

3 Measurement and Analysis

- Benefits
 - Provides quantitative determination of how well you are doing relative to mission objectives, other projects, the past, and/or the plan
 - Provides a mechanism to monitor selected aspects of a project to provide timely information for management decision making
 - Improves communication
 - Encourages appropriate behavior
 - Pinpoints opportunities for improvement

3 Measurement and Analysis

- Who makes it happen?



Project Leads

2 Requirements Management

- Requirements management documents and verifies requirements and requirements changes that meet customer expectations
- Key concepts include ...
 - Understand operational concepts and system-level requirements
 - Establish and manage changes to detailed software requirements
 - Maintain bi-directional traceability
 - Identify inconsistencies between requirements and work products

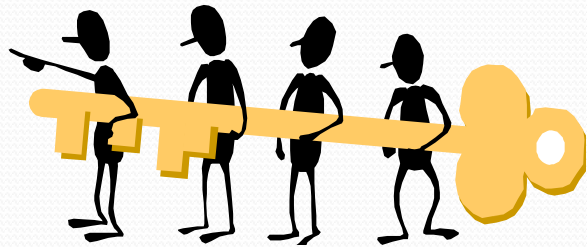
2 Requirements Management

- Benefits

- Encourages development of high-quality requirements and elicitation of requirements from customers
- Bi-directional traceability enables close evaluation to eliminate lower level requirements that do not support mission requirements
- Allows detailed requirements definition and tracking to ensure product completeness
- Enables requirements change management to ensure product lifecycle integrity
- Helps avoid requirement creep

2 Requirements Management

- Who makes it happen?



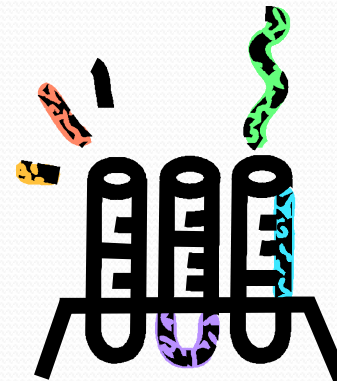
Design/Implementation



Requirements Team



Customer/User



Test Team

1 Planning & Monitoring

- Project planning defines and documents the necessary project activities so that they may be monitored to ensure deviations are recognized soon enough to take corrective actions
- Key concepts include ...
 - Develop and maintain the project plan/schedule
 - Establish work product and task estimates
 - Define communication and monitoring methods
 - Conduct milestone/progress reviews

1 Planning & Monitoring

- Key concepts (cont'd)
 - Obtain commitment to the plan
 - Monitor against the plan
 - Estimates
 - Commitments
 - Risks
 - Stakeholder involvement
 - Take corrective actions when necessary

1 Planning & Monitoring

- Benefits
 - Ensures timely determination of cost/schedule impacts
 - Allows standardization and quantifying of project goals
 - Enables tracking of project schedule milestones
 - Provides insight into technical/cost risk management
 - Identifies stakeholder participation issues
 - Tracks/controls corrective actions to closure
 - Monitors management of project data

1 Planning & Monitoring

- Who makes it happen?



Project Management



Project Leads

Honorable Mention

- Keys to keep all these processes working well...
 - Sponsorship (management support)
 - Stress the importance of maintaining good processes
 - Ensure that adequate resources are available to support processes
 - Standardization of processes
 - Have a library of process assets --process descriptions, tools, templates, lessons learned
 - Use a measurement repository to capture organizational “norms”, improve cost estimation and gauge success of improvements
 - Develop tailoring guidelines to make processes reasonable for all types of projects



Space Shuttle Launch from Disney's Castle

CMMI Benefits at NASA

- Reduces risk of software failure increasing mission safety
- More predictable software cost estimates and delivery schedules
- Smarter buyer of contracted software
- More defects found and removed earlier
- Reduces duplication of efforts between projects
- Increases ability to meet the challenges of evolving software technology
- Software development planning improved across the Agency
- NASA's contractor community has heard the word that the bar has been raised with respect to software engineering and is responding appropriately

